Chemical Changes in Standing Cereal Straw Residues in Chem-Fallow and its relationship to N, P, and S Availability in Two Cropping Systems

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In recent years, conventional mechanical fallow has slowly shifted to chem-fallow on the prairies. With the chemical system of weed control, the straw is not mixed with the soil until seeding the following spring; meanwhile the nutrient status of the straw may change during the fallow period. The C:N, C:P, and C:S ratios may be expanding, resulting in a potential for increased immobilization once the straw is worked into the soil.

To determine how the nutrient status of the standing straw residue may be changing, four chem-fallow treatments were chosen and the standing cereal residue sampled at six week intervals starting in June of 1993. Two treatments are located in the Brown soil zone (site 1) and two are located in the Black zone (site 2). At site 1 there is a treatment of wheat-fallow and a treatment of barley-fallow. At site 2 there is a wheat-fallow treatment and a treatment of wheat in rotation with flax, peas, and fallow. Site 1 is pre-tilled prior to seeding while site 2 is direct-seeded.

Results for the first three months of the chem-fallow period reveal that water extractable sulfate, phosphate, and total nitrogen decrease over time accompanied by a widening of the C:N, C:S and C:P ratios. This may suggest a greater immobilization potential per unit weight of straw when worked into the soil.

Key Words: Chem-fallow, mechanical fallow, nutrients, C:N, C:P, C:S, immobilization

Introduction

Traditional soil management in the Brown, Dark Brown and parts of the Black soil zone has included a fallow period after the cropping year. This mechanical fallow operation is used to control weeds, to build up the moisture reserve, to manage residue and to reduce compaction of the surface (Grant and Lafond, 1993). However, tillage may also lead to breakdown of organic matter, the spread of salinity and an increased susceptibility to wind and water erosion (Campbell, et al., 1990).

To help combat some of these problems, management systems which maintain crop residue (standing stubble) over the fallow period have increased in usage (Follett et al., 1987). With the advent of reasonably priced non-selective herbicides, mechanical fallow has slowly shifted to chemical fallow (chem-fallow). Attractive features include reduced soil erosion, less on-farm energy use, and more available soil water (Unger and

McCalla, 1980). With the chemical system of weed control, the straw is not mixed with the soil until seeding the following spring; meanwhile the nutrient status of the straw may change during the fallow period. The C:N, C:P and C:S ratios may be expanding, resulting in a potential for increased immobilization once the straw is worked into the soil.

The present study was undertaken to determine if the nutrient status of water soluble ammonium, nitrate, total nitrogen, phosphate and sulfate from standing straw residue does decrease over time (spring-fallow period to spring of crop year). Total carbon will also be determined and used in conjunction with the various nutrients to determine potential immobilization.

Materials and Methods

Description of Experimental Sites

Four chem-fallow treatments were chosen at two sites and sampled every six weeks starting in June/93. Site one is located in the Brown soil zone near Central Butte. It consists of a wheat-fallow and a barley-fallow treatment. At this site, the field will be pre-tilled prior to seeding. Sampling consisted of cutting standing straw from three replicates of the plot. Site two is located in the Black soil zone near Indian Head. It consists of a wheat-fallow treatment (LTRot plot) and a treatment of wheat in rotation with flax, peas and fallow (ZT plot). At site 2, direct seeding will take place in the spring. Sampling consisted of cutting residue from 4 replicates at each plot.

Determination of Nutrient Status

All residue was finely ground with a cyclone sample mill. Total carbon was determined using the LECO CR 12 infrared absorption carbon analyzer. For nutrient determination, 1g of ground residue was shaken with 40 ml of distilled water and an anion exchange membrane (AEM)(Schoenau and Huang, 1991) in a 250 ml flask for 1 hour. The AEM was then eluted in 0.5 M HCl for 1 hour and the eluent analyzed for phosphate, sulfate and nitrate. Sulfate was determined on the ICP while nitrate and phosphate were determined by Technicon automated colorimetry. The remaining residue/water mixture was filtered through a #40 Whatman filter and then millipored and analyzed for ammonium by Technicon automated colorimetry. Total nitrogen was determined by Technicon automated colorimetry after digestion of 2 ml of filtrate in potassium persulfate in the autoclave followed by conversion of all nitrogen to ammonium with Devarda's alloy.

Results and Discussion

Total Carbon

Over the first six months of sampling there has been only a slight decrease in the percentage of carbon present in the wheat and barley straw residue at site 1. Initial values of carbon for the wheat and barley were 43.2 and 42.3% respectively with values at the sixth sampling decreasing to only 42.4 and 41.3% respectively.

At site 2 only a small change has occurred. At this site the LTRot plot has increased from 42.8 to 43.7% carbon while the ZT plot has increased from 43.0 to 43.9% carbon. At both sites the changes are not significant and therefore the percentage carbon can be considered constant throughout this period.

C:TN

Nitrate is almost undetectable in any of the residues so only total nitrogen (TN - largely organic) is included in C:TN ratios. At both sites (and all treatments), TN has decreased in the first three months of sampling. This has resulted in an expanded C:N ratio as seen in figure 1 and 2.

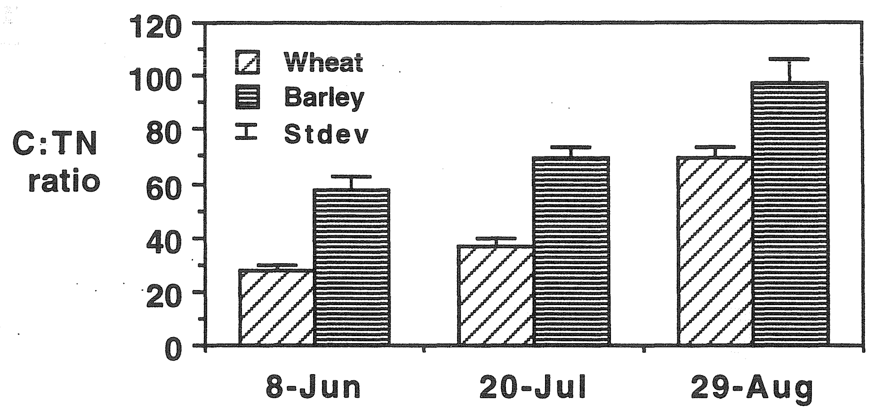

Figure 1 The carbon to nitrogen ratio from water extracted chem-fallow straw at site 1.

It is apparent that the amount of nitrogen present in the different straw residue changes with both crop and site location. Figure 1 illustrates the large differences in C:TN between wheat and barley residue. In figure 2 wheat straw C:TN ratio is compared under two cropping regimes. The ZT plot receives more nitrogen at seeding which helps explain the low C:TN

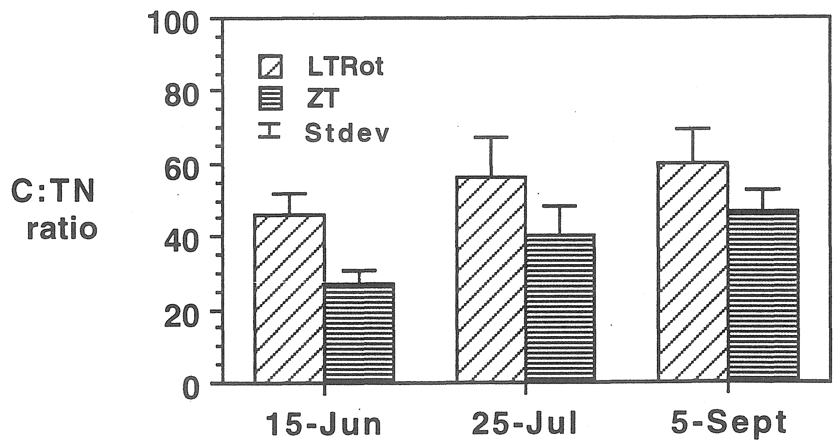

Figure 2 The carbon to nitrogen ratio from water extracted chem-fallow straw at site 2.

ratios compared with the LTRot plot. At either site, regardless of crop or nutrient applied, the trend of an expanding C:TN ratio is present. As this ratio expands so does the increased potential for immobilization of soil nitrogen once the straw is worked into the soil.

C:PO4

Water soluble phosphate in the straw residue is available in much lower quantities than TN; therefore the C:PO4 ratio is much larger than the C:TN ratio. The ratio of C:PO4 is approximately ten times the magnitude of C:TN (figure 3 and 4). The C:PO4 ratio trends are similar to the C:TN

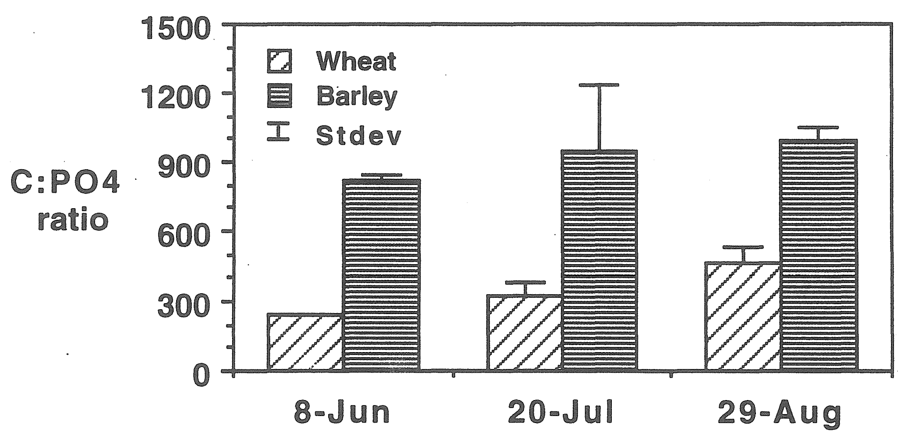

Figure 3 The carbon to phosphate ratio from water extracted chem-fallow straw at site 1.

trends, but changes between sampling dates are much smaller, possibly due to the smaller pool of available phosphate in the straw. With the phosphate we are again seeing sharp differences between the wheat and barley (figure 3) and the two cropping regimes (figure 4), but variation between replicates (stdev) is much larger at site 2.

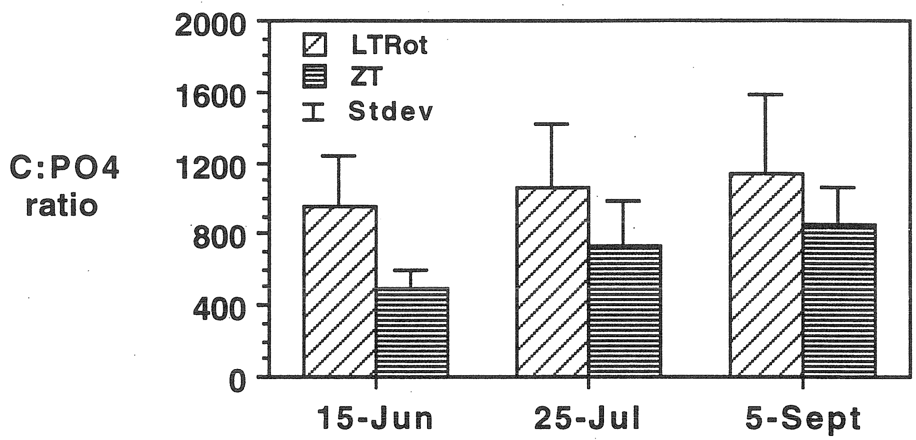

Figure 4 The carbon to phosphate ratio from water extracted chem-fallow straw at site 2.

C:SO4

Water soluble sulfate (SO4) appears to be a very minor and variable component of the straw residue. The C:SO4 ratios are between 25 to 70 times larger than the C:TN ratios. Variation among replicates at site 1 (figure 5) was so large it was not included in the graph. Site 1 has a large

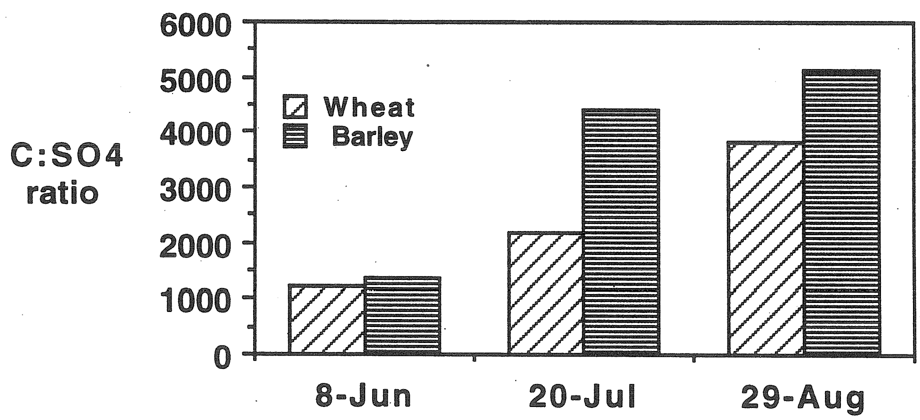

Figure 5 The carbon to sulfate ratio from water extracted chem-fallow straw at site 1.

initial expansion in the C:SO4 ratio, but less change with time. Site 2 (figure 6) has a consistent expanding C:SO4 ratio with much less variation between replicates.

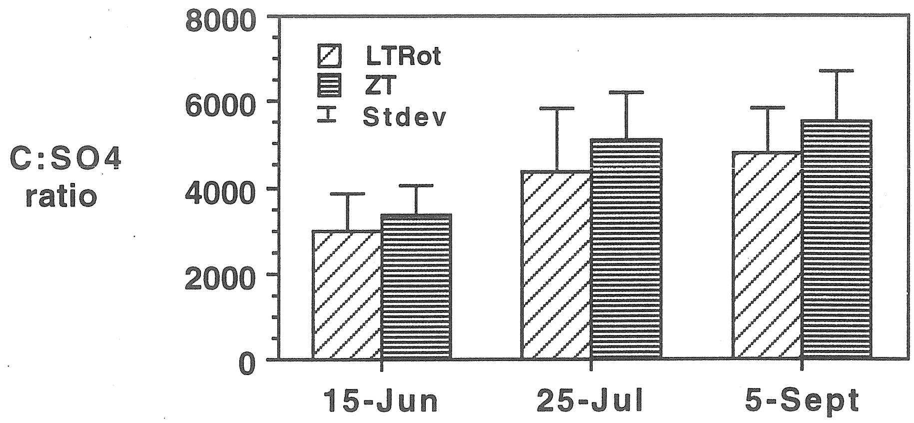

Figure 6 The carbon to sulfate ratio from water extracted chem-fallow straw at site 2.

Conclusion

Results for the first three months of the chem-fallow period reveal that water extractable nitrogen (TN), phosphate and sulfate decrease over time at all sites. The percentage carbon does not change appreciably at any site. This results in a widening of the C:TN, C:PO4 and C:SO4 ratios. This may suggest a greater immobilization potential per unit weight of straw when worked into the soil.

Although most microbial activity for mineralization or denitrification is found in the soil in this system, there is some evidence to suggest that there may be some activity in the standing straw. The total nitrogen content was reduced after each 6 week period, but ammonium only had a slight decrease after the first 6 week period and then rose sharply to levels larger than the initial ones. This may suggest partial breakdown of this largely organic nitrogen pool into the ammonium form.

Currently a growth chamber experiment is underway to determine if this potential immobilization of the above nutrients is significant enough to warrant additional fertilizer at seeding time to counteract this affect. Smith and Sharpley, 1993, stated that only 1 to 7 kg N ha^{-1} was immobilized by incorporating straw, but that was fresh, finely ground straw not chem-fallow straw.

Acknowledgements

Potash and Phosphate Institute of Canada

Saskatchewan Ag. Development Fund

Indian Head Experimental Farm Plots (Dr. Guy Lafond)

Schoenau Farm (Dr. Jeff Schoenau)

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